



NASA's
Game Changing Technology
Industry Day
June 29-30, 2016



**Advanced Near Net Shape
Technology (ANNST)**

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TECHNOLOGY DRIVES EXPLORATION



Advanced Near Net Shape Technology: Integrally Stiffened Cylinder Process



- *Integrally Stiffened Cylinder (ISC) Process* - Revolutionary manufacturing method to produce stiffened aerospace structures
- The ISC process offers ~50% reduction in manufacturing cost and ~10% mass savings
- This technology targets launch vehicle cryogenic propellant tanks, but will also benefit intertank and dry bay structures



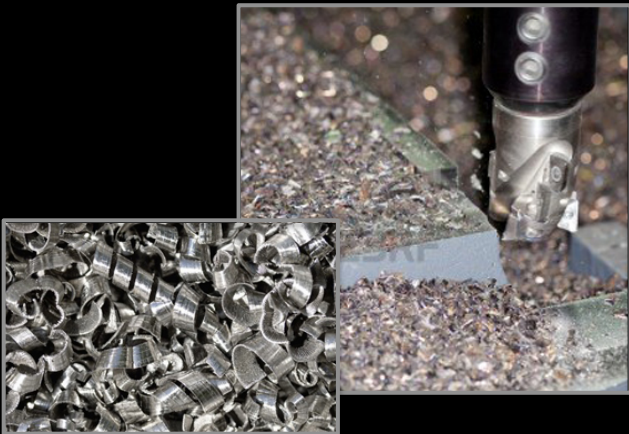


Traditional Cryogenic Tank Manufacturing



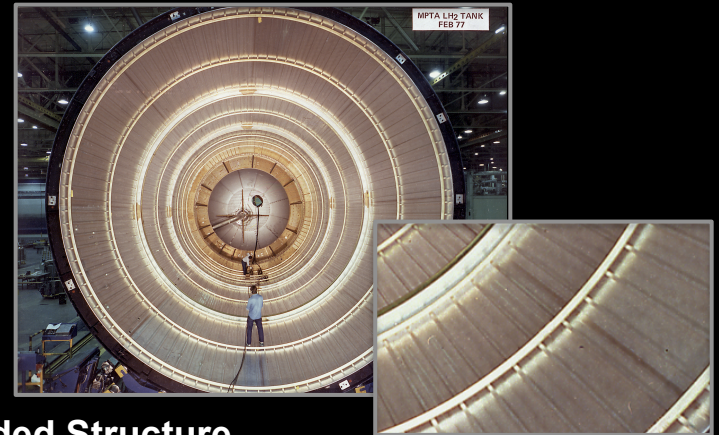
Problem

- Machined/welded construction of launch vehicle cryotanks is expensive, heavy, and risky
- Majority of launch vehicle cryotanks are welded and machined based on manufacturing principles from 1950's



Integrally Machined

- 90% Scrap Rate *
- Approx. 540,000 lbs. Chips *
- \$8M Chips *
- Environmentally Unfriendly



Welded Structure

- Material Property Knockdown
- Potential Weld Defects
- Weld Lands Concentrate Load
- Approx. 0.5 Miles of Welds *

Solution

- Use innovative metals forming techniques to manufacture cryotanks which are cheaper, lighter, with fewer welds

** Figures based on Space Shuttle External Tank*

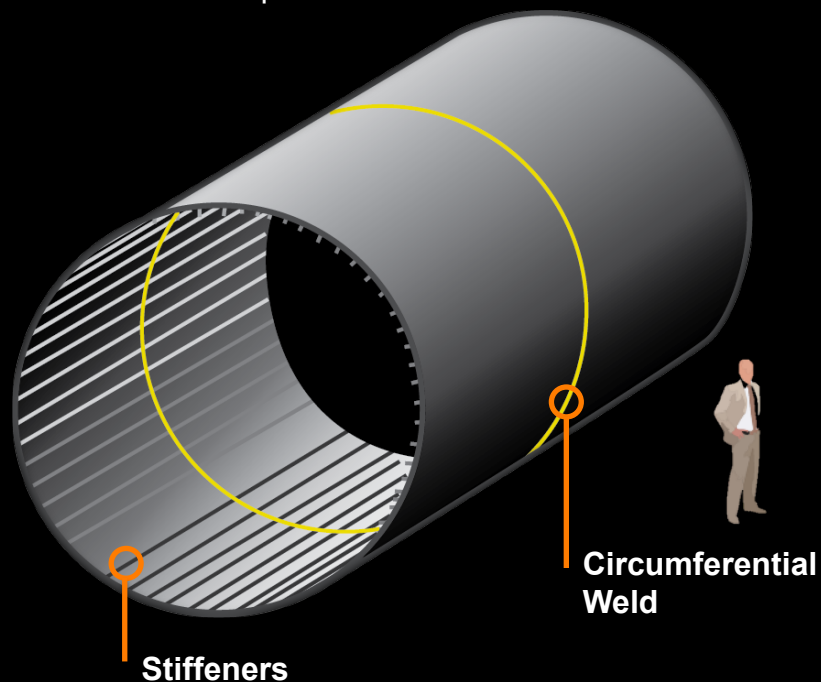


Comparison of Manufacturing Technologies



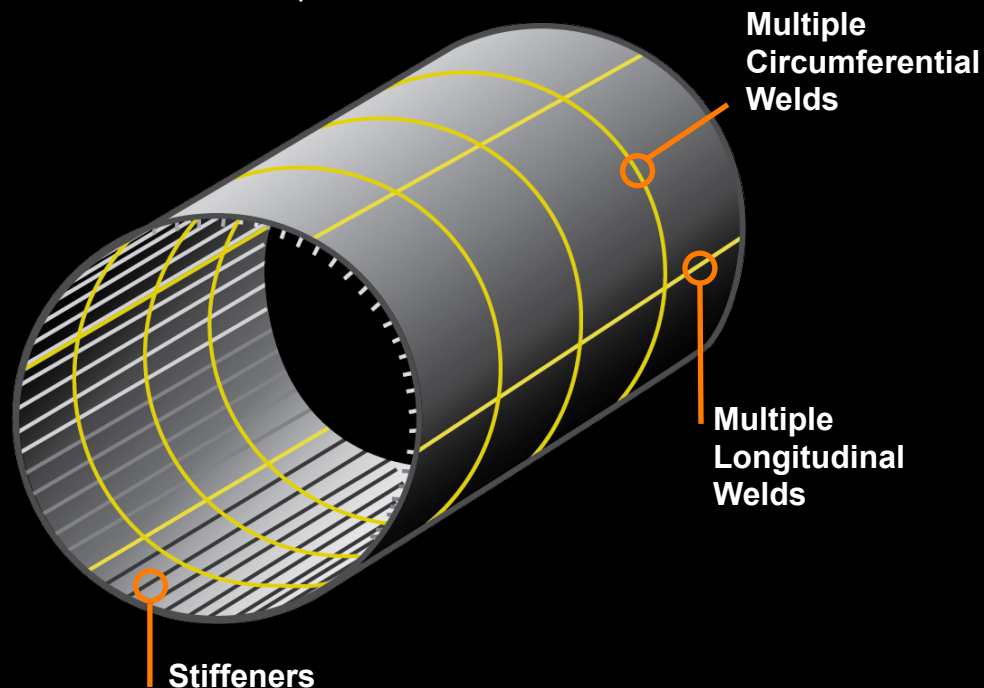
Integrally Stiffened Cylinder (ISC) Process

Near-net shape construction



Conventional Fabrication

Multi-piece, welded construction



Key Benefits of ISC Process

- Minimizes machining
- Eliminates longitudinal welds
- Reduces number of circumferential welds



Cost-Benefit Analysis of the Integrally Stiffened Cylinder (ISC) Process



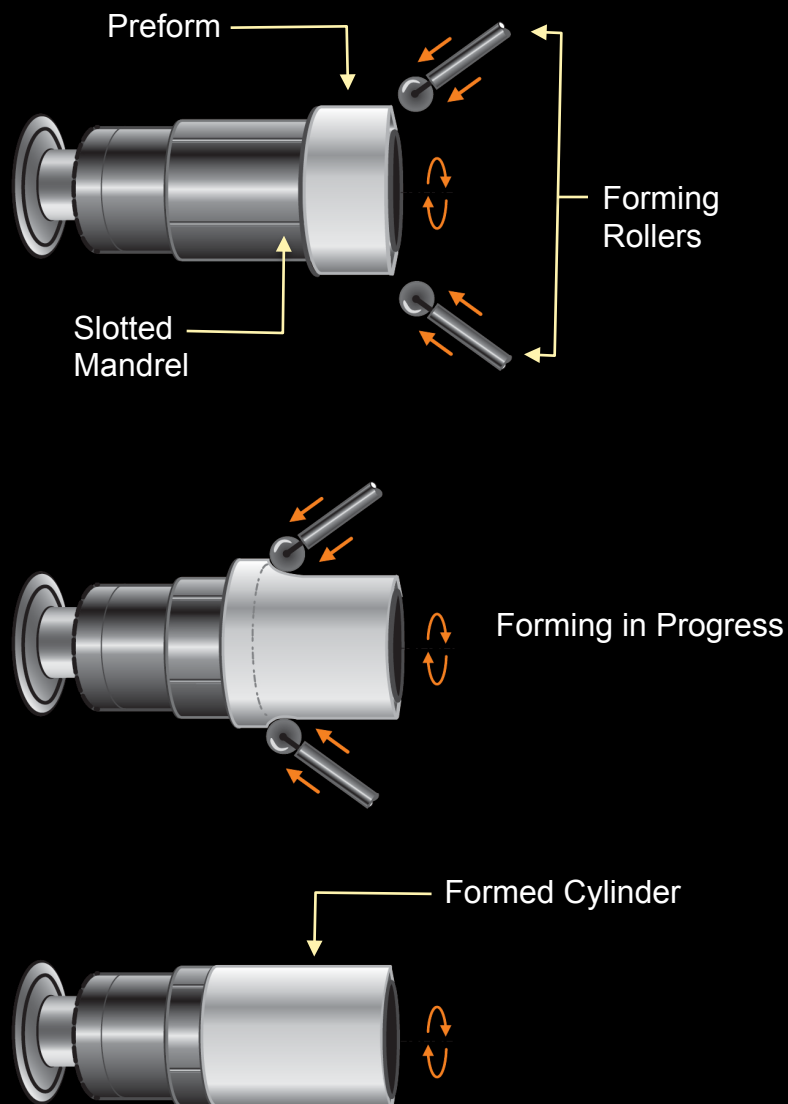
ISC Process vs. Conventional Fabrication

Savings	NASA	MT Aerospace
Cost	52 %	41 %
Mass	7 %	5 %

- Cost reduction attributed to:
 - Reducing labor for machining, welding and inspections
 - Truncating manufacturing schedule by 60%
- Mass reduction by eliminating longitudinal welds and associated weld lands
 - Additional mass savings may be realized through design optimization
- Capital investment for ISC equipment estimated at \$8M
 - ROI after fabrication of 5 cryogenic tank barrels
 - Capital investment equals material savings in one Shuttle External Tank scale barrel



Integrally Stiffened Cylinder (ISC) Process



Fabrication of Stiffened Structures with the ISC Process

- A thick aluminum pre-form is mounted on a slotted mandrel
- Mandrel rotates while forming rollers apply force to lengthen the cylinder and thin the wall
- Rollers force material into slots producing stiffeners

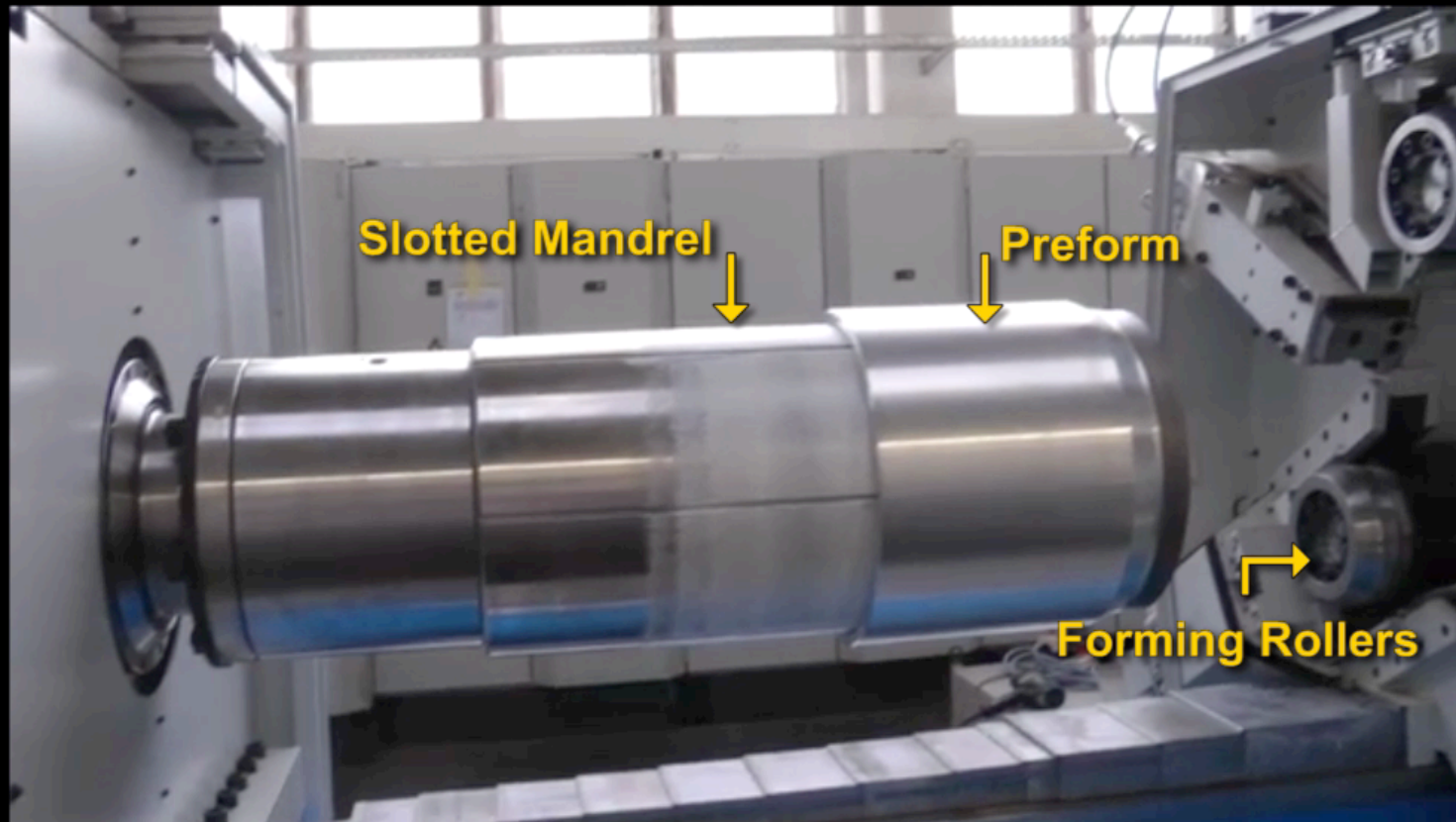




Video of the Integrally Stiffened Cylinder Process



Integrally Stiffened Cylinder Forming Equipment





Maturation of the Integrally Stiffened Cylinder Process



Lab to Launch in 4 years

**Proof of Concept
with Al-Li Alloy**



- 0.2 in. tall stiffeners
- 8 in. diameter



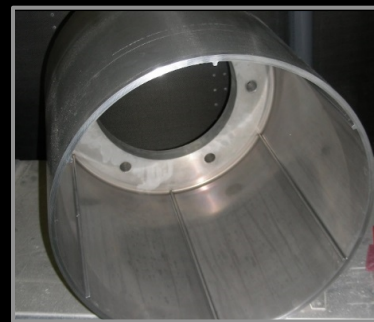
**Increased Stiffener
Spacing and Height**



- Multiple stiffener shapes
- 0.75 in. tall stiffeners
- 8 inch diameter



**Scaled-up 6061 Aluminum
Stiffened Cylinder**



- 17 in. diameter
- 20 in. length



**Cryogenic Tank
Height Stiffeners**



- 1 in. tall stiffeners
- 17 in. diameter

Sounding Rocket Flight Demonstration Oct. 7, 2015

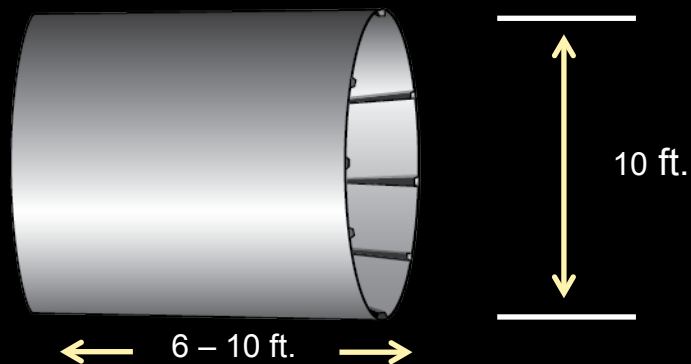




Scale-Up of Integrally Stiffened Cylinder (ISC) Process

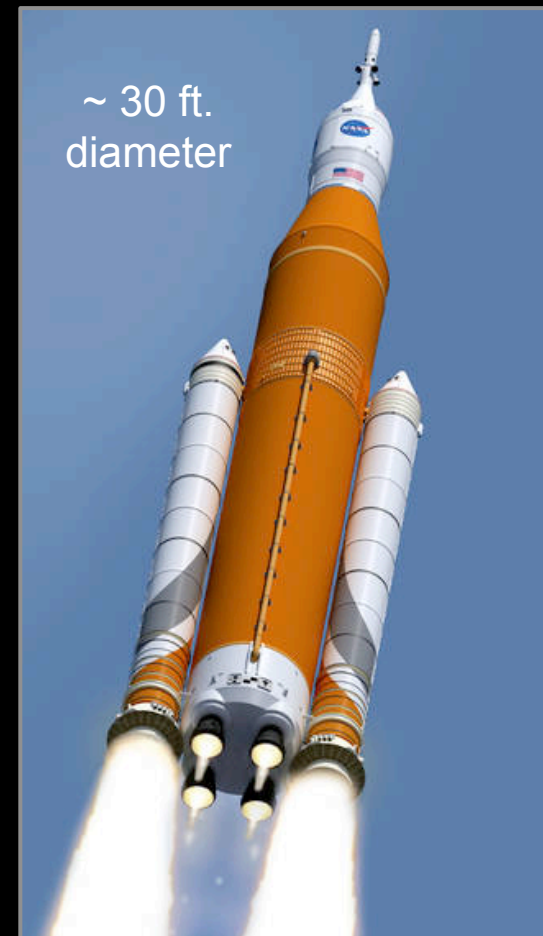


Scale-Up to 10 ft. Diameter



- Partnering with Lockheed Martin, ESA, and MT Aerospace
- Enabled by utilizing existing infrastructure at MT Aerospace
- 10 ft. diameter stiffened cylinders have application to US and European launch vehicles

Long-Term Vision: SLS Scale Cryotanks





International Partnerships



- **Lockheed Martin**
 - US industry perspective and technology infusion into Lockheed Martin launch vehicle systems



- **MT Aerospace**
 - Commercial aerospace manufacturer
 - Spin forming expertise and collaboration throughout ISC process development



- **European Space Agency (ESA)**
 - Future Launcher Preparatory Program (FLPP)
 - Infusion of ISC technology into upgrades for Vega & Ariane rockets



- **DLR (German Aerospace Center)**
 - Partnering to explore limits of stiffer size



- **Leifeld Metal Spinning**
 - Spin forming equipment manufacturer
 - Potential ISC equipment supplier for US industry



- **International Technologies, Inc.**
 - US importer of spin forming equipment



Contact Information



For More Information About The Integrally Stiffened Cylinder Process Or To Discuss Potential Collaboration Efforts

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